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JOHN R. MOHLER, Chief

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CITY MILK PLANTS: CONSTRUCTION AND ARRANGEMENT.

By Ernest Kelly and Clarence E. Clement, *Dairy Division.*

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STATEMENT OF PRESENT CONDITIONS.

The market-milk industry has assumed enormous size and importance. By market milk is meant milk consumed in the fluid state, as distinguished from milk used for butter, cheese, condensed milk, and other products. It is estimated that in 1917 more than 16 billion quarts of market milk were consumed in the United States, which at 10 cents a quart would have been worth more than $1\frac{2}{3}$ billion dollars. Of course much of this milk was used on farms and in small towns, but probably not less than one-third was used in the larger cities. The greater part of the city milk was handled by so-called "middlemen" in city milk plants. These milk plants represented an investment of about 100 million dollars in buildings and machinery. The cost of land and delivery equipment would bring the total to considerably more.

Such an important business entails a great responsibility. Infants, children, and invalids, as well as healthy adults, depend to

a great extent upon market milk. The supply must be brought sometimes from a distance of 300 or 400 miles, pasteurized, bottled, and delivered to the consumer generally each morning before breakfast. Furthermore, the milk must be handled under rigid sanitary conditions. For this business the modern city milk plant has been developed. These plants are constantly being remodeled, and new ones are being built to meet the latest advances in sanitation.

The purpose of this bulletin is to furnish specific information on the construction and arrangement of modern milk plants as an aid to those who wish to build new plants or remodel old ones. The information presented is based upon data obtained from surveys made of many of the principal plants in the larger cities of the United States.

PRIMARY CONSIDERATIONS IN ESTABLISHING A PLANT.

While starting a milk plant which insures a safe and adequate milk supply for a community is a laudable enterprise, it must be remembered that such ventures are not always successful. Many milk plants have failed, not because of faulty management or changed conditions, but because the milk plant should not have been established in the first place. Before the prospective operator engages in the milk business the following questions should be answered to his satisfaction.

1. Is the person who is to manage the plant familiar with the milk business? Unless a capable manager can be obtained the chances of success will be greatly lessened, as the success of a milk business depends primarily upon the manager. Besides being a good business man, the manager must be acquainted with the details of handling milk and of milk-plant operation. A man may have the proper character, personality, and business ability to manage some other kind of business and yet make a failure of the management of a milk plant, because he lacks the technical knowledge required.

2. Is there capital enough available to equip and operate a modern sanitary plant until it reaches a paying basis?

3. Is there a sufficient supply of milk of proper quality available or can enough be made available to operate the plant successfully?

4. Is there a steady demand for milk in the locality under consideration and is this demand being met by dealers already in the business?

5. What type of competition will be met with?

6. What is the attitude of the local health department? A capable health department can be of great help to a plant that is putting out a high-grade product.

7. What is the local labor situation?

8. Can the householders in the community be taught the value of milk as a food and be led to increase their demand? Are they able to pay a fair price for a high-grade product, and will they pay their bills promptly?

There are also minor considerations, but if the foregoing conditions are favorable the advisability of establishing a new plant in the vicinity will be greatly enhanced.

HINTS TO PROSPECTIVE BUILDERS.

The construction of a city milk plant requires careful study and planning. The building represents a large investment, as is shown in Table 8 under "Investment in milk plant." It is important, therefore, that the plans be carefully laid. The efficiency of the plant depends to a large degree upon the type of equipment used and the arrangement of the various rooms and machinery. It is possible for a well-arranged plant to effect great economies in labor, while a poorly planned plant may become a continual source of expense because of the extra labor required.

Any one contemplating building a new plant will do well to visit various up-to-date plants in different cities to get the latest ideas on construction, layout of rooms, and equipment. If it is impossible to visit other plants, plans and specifications sometimes can be obtained and ideas gained from them. By combining other dealers' ideas with his own the prospective builder can usually incorporate the best features of all in the new plant.

After selecting a site for the plant and determining about what is needed, the prospective builder should explain his general plan to a competent architect, who will draw up tentative sketches and plans which may then be studied in detail. Of course the type of machinery to be used must have been previously decided upon, since the general arrangement of the plant will depend a great deal on the type used.

It may be well to have several plans drawn, each adapted to a particular type of machinery. In case changes are found necessary they should be made in the plans before beginning the construction, as it is expensive to make alterations. It would be well also to have the plans reviewed by others experienced in the business and by health officials before the final plans are drawn.

After the plans and specifications of the building have been decided upon, bids should be obtained from several contractors in order to get the work done as reasonably as possible.

For a plant of small capacity much less detail is necessary and the plans can be completed frequently without the aid of an architect.

LOCATION OF PLANT.

The principal points to bear in mind in locating a milk plant are:

1. Ease of access from as many sides as possible.
2. Value of property.
3. Cost of getting the milk to the plant.
4. Proximity to distribution center.
5. Advertising possibilities.
6. Opportunity for retail counter cash trade.
7. Nearness to city water supply and electric power.
8. Avoidance of heavy traffic surroundings.
9. Good drainage.
10. Pure air and clean surroundings.

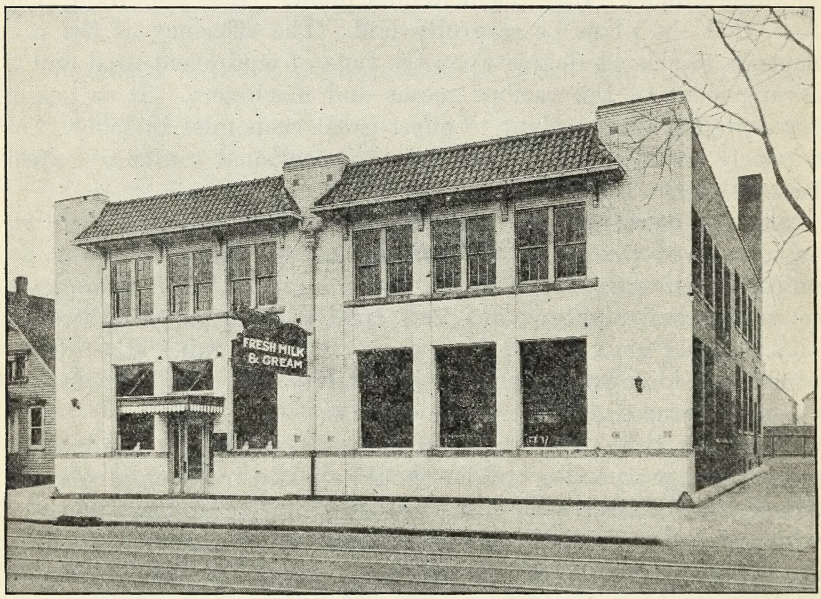

FIG. 1.—Exterior of a modern city milk plant.

Ease of access to the plant is very important. It is difficult to arrange a plant economically and conveniently unless it can be approached from at least two sides. A plant on a corner lot with an alley in the rear is desirable, but is seldom obtained in the down-town section of a city without great expense.

The high valuation of down-town property in many cities would be prohibitive for the location of a milk plant. In small cities, however, the extra advertising value and the cash trade gained by having the plant in the down-town section would often warrant such a location.

The cost of getting milk to the plant is an important consideration. If the bulk of the milk is received by railroad it may be advantageous to locate the plant near the railroad station, but if the milk is handled

largely by truck, the vicinity where most of the milk comes into the city would be a convenient location. In case a large proportion of the milk is to be handled as bulk goods or wholesale deliveries, the wholesale section would have the advantage. If branch plants are to be established it may be well to locate the main plant where it can most easily receive the milk from the railroads. It is much less expensive to transfer bulk goods by truck than bottled goods, so that many dealers find it advantageous to have a main plant where most of the milk is received and to have branch plants near centers of distribution. Usually most of the trade of the branch plants is retail, while the down-town plant handles the greater portion of the wholesale trade. One plant having two branch plants had routes as follows:

	Wholesale routes.	Retail routes.
Main plant	12	39
Branch No. 1	4	26
Branch No. 2	3	28

By locating the plant near the center of distribution, delivery costs may be considerably lessened and in some cases two delivery trips may be made during the day.

Some dealers plan to establish the main plant in or near the section of the city where considerable development is anticipated. In this way they endeavor to obtain the trade of people moving into that section and the plant itself acts as an advertisement.

To serve as an advertising medium the plant must be situated where there is considerable travel, as in a retail shopping district, or at a street-car transfer point. The value of this form of advertising depends upon local conditions. In a small city it may be of considerable importance. The retail counter cash trade is usually of small importance in a large city, but in a small or medium-sized town this trade is often well worth considering. A plant on a much-traveled highway should draw this trade.

In few cities is there difficulty in getting an adequate supply of water and electricity, but, nevertheless, it is well to consider these items. Congestion of traffic is of small consequence in a small town, but in a large city it may assume considerable importance.

Good drainage for the plant and clean surroundings are essential for an up-to-date plant. Some plants are opposite parks and the air is very free from dust, while at plants in a thickly settled part of the city it is often necessary to filter the air that comes into the building.

In general, there are three locations in cities that may be selected for a milk plant: (1) In the wholesale district near the railroad,

(2) in the down-town retail section of the city, and (3) in the residential section. Heretofore it has been the general custom to locate the plant in the wholesale district near good railroad facilities. The tendency in recent years, however, has been to build it near the center of distribution rather than near the railroad terminal.

The advantages of having a milk plant in the wholesale district are:

Railroad facilities make it more convenient for receiving the milk.
It is a considerable distance from the residence districts, and there are less likely to be complaints of noise, smoke, etc.

The disadvantages of locating a plant in the wholesale district are:

It is away from the center of distribution.
There are no advertising benefits.
The district usually is rather insanitary and the air is filled with dust.
Property is often expensive.
Few retail counter sales are made at the plant.

The chief advantages of being in the retail district are:

Advertising benefits.
Retail counter sales, which are valuable not only for the actual sales made but for the new trade obtained thereby.

The principal disadvantages in the retail district are:

Property is expensive.
Less convenient for receiving milk.
May not be convenient for distribution.
More street traffic.

The advantages of a plant in the residential district are:

It is nearer the center of distribution and property is less expensive.
Retail counter sales are made and new customers obtained at the plant.
Pure air.
Less congestion of traffic and more quiet surroundings.

The disadvantages in the residential district are:

Poor railroad facilities.
Less advertising benefit.
Possible restrictions in regard to operation.

CLASSES AND TYPES OF PLANTS.

Plants may be classified, according to the method of handling the milk in the plant, into the following 6 classes:

1. *Gravity, more than one story.*—In this class of plants the milk in cans is elevated above the first floor and dumped. It then flows by gravity through pasteurizing and other machinery without the use of a milk pump.

2. *Gravity and pump, more than one story.*—Milk is elevated in cans above the first floor and dumped. It flows by gravity through

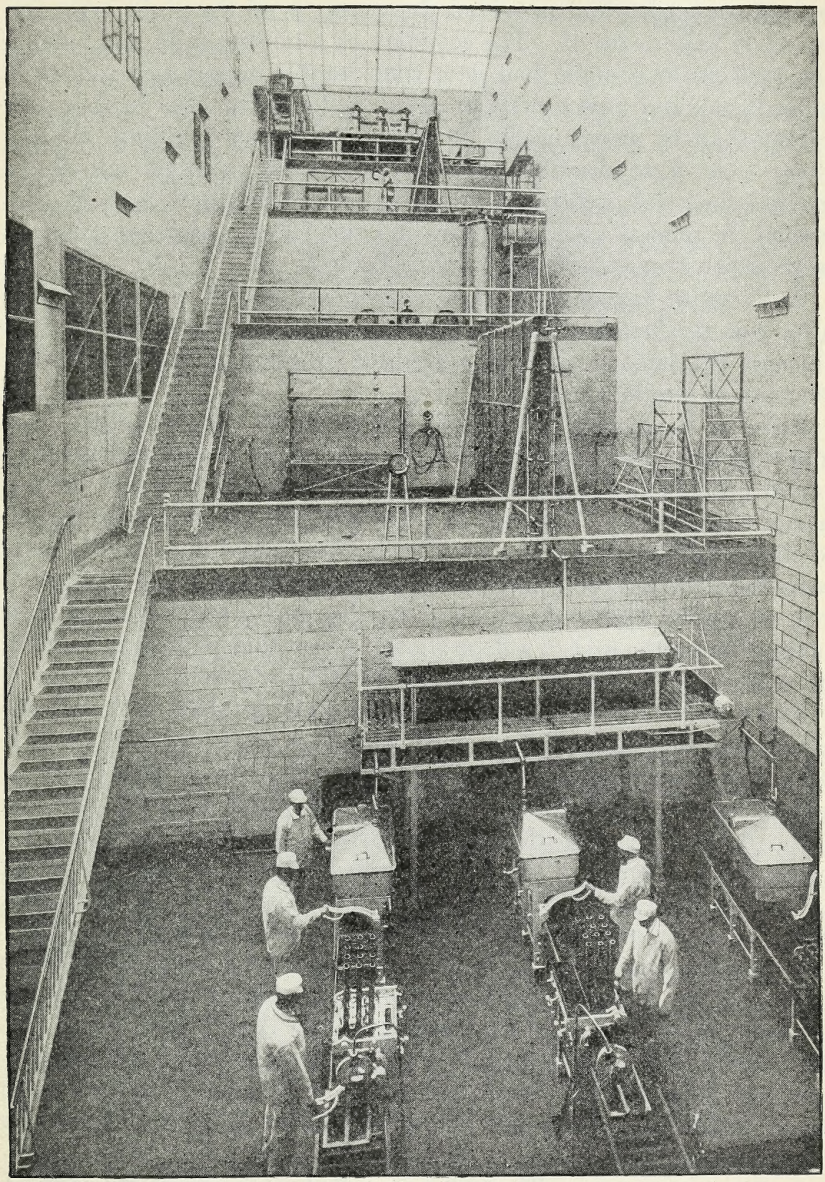

FIG. 2.—General view of equipment in gravity plant, class 1.

part of the machinery, but pumps are used also before it reaches the filler.

Classes 1 and 2 are rather uncommon, as most dealers seem to consider it uneconomical to elevate the milk in cans above the first floor.

From the ideal sanitary standpoint class 1 is to be preferred. Most dealers, however, do not consider it objectionable to pump the milk before pasteurization, provided the pump is of the right type and properly taken care of. The economy of dumping milk and leaving the cans on the ground floor is of considerable importance and much labor, time, and power may be saved by handling cans in that way rather than by elevating the full cans and, after dumping, sending them back on an elevator. Where there is not room enough on the ground floor for weighing, sampling, and grading it may be convenient to send the milk upstairs in cans. This system as a rule is more expensive, as is shown later in Table 2.

3. *Pump to higher level, then gravity.*—The milk is dumped into a tank on the first floor and pumped to a floor above, whence it flows through the various pieces of apparatus by gravity, without the further use of a milk pump.

Some of the most modern large plants, which vary in height from 2 or 3 stories upward, come under class 3. It is less objectionable to pump milk before pasteurization, when contamination can do less harm, than after. This type of plant also has the desirable feature of dumping and weighing the milk on the ground floor and is more economical in receiving milk than plants in classes 1 and 2.

4. *Pump to higher level, then gravity and pump.*—The milk is pumped from the first to a floor above. From that point it is handled by pumps, or partly by pumps and partly by gravity.

Many of the larger plants belong to class 4. This type has the economical advantages of the plants of class 3 and in addition permits greater economies in labor by the fact that the various pieces of apparatus are comparatively close together, and in some cases on fewer floors. In most of the plants of class 4 milk is pumped after pasteurization and the number of milk pumps and length of milk piping required are usually greater than in plants of the other classes. Many of the plants studied in this class were comparatively old.

5. *Gravity, one story.*—The milk is handled on one floor without milk pumps. Large quantities of milk can not be handled rapidly in such plants, and only the smaller plants come under this head. The plants of this class include a few small ones where the pasteurizer was raised on a platform and the milk dumped directly into it. Those handling between 501 and 1,000 gallons daily were raw-milk plants.

6. *Pump, one story.*—The milk is handled on one floor, one or more pumps being used. Class 6 includes some of the less up-to-date plants, which are usually frame buildings, built some time ago. The amount of milk piping required is comparatively large. Many of the smaller plants come under class 6; 48 out of a total of 55 handling less than 500 gallons each daily were in this class. A few of the

larger plants were included, but in most cases they were old and poorly arranged. In one of the latter as much as 300 feet of milk piping was used. Considerable economy of labor is often possible in plants of this type, however, as the one-floor system usually requires fewer men.

It is evident that plants in class 2 have few advantages over those in classes 3 and 4. They have the disadvantages mentioned in regard to time and labor of getting the milk upstairs, and pumps are used after pasteurization, which is not the case in classes 1 and 3, in which milk flows by gravity from the pasteurizer through the remainder of the equipment. One advantage they may have over the plants of class 3 is that less milk piping is required, for there is no piping from the ground floor to the receiving room upstairs.

A total of 174 plants of the principal dealers in the larger cities of the United States falls into the following classes:

Class.	Plants.	Class.	Plants.
1	2	5	10
2	5	6	83
3	17		
4	57	Total	174

Of the 83 plants in class 6, 48 each handled daily 50 gallons or less, and of the 57 plants in class 4, 29 handled 3,000 gallons or more each.

CONSTRUCTION OF PLANT.

SIZE OF BUILDING AND NUMBER OF STORIES.

In planning a milk plant, provision should be made for a building large enough to accommodate a reasonable expansion of the business. If possible the building should be so laid out that by the addition of more units of machinery the capacity of the plant can be increased from time to time without interfering with the convenient arrangement of the apparatus. Sometimes provision is made for adding another story.

A study of 105 representative milk plants showed that most of those handling less than 1,000 gallons daily have 1 story, while those handling from 1,000 to 5,000 gallons have 2 stories. Plants handling more than 5,000 gallons varied from 2 to 5 stories.

TYPE OF BUILDING.

The type of building selected depends upon local conditions and the type of machinery to be used. The more recently built plants are usually from 2 to 3 stories. There are but few advantages in a higher building, as labor requirements increase with the height. A gravity system for handling milk can be arranged as well in a

plant of 2½ stories as in a higher one. By either elevating or pumping the milk to a tank 2 or 2½ stories high, gravity will do the work; that is, the milk will flow through the clarifier and the pasteurizer into the bottle-filling machinery without the use of a pump.

The principal advantage of building a higher plant is the smaller ground area needed when the plant is in a thickly settled part of the city; however, the tendency to build farther away from the downtown section is increasing, so that this consideration becomes of minor importance. The appearance of the building from the street is important, as it serves as an advertisement.

While the size of the plant as well as the number of stories depends on the quantity of milk to be handled, it should be so planned that one man can remain on one floor and not have to go from one floor to another in doing his work. Much time may be wasted if the men have to go upstairs and downstairs in their daily duties.

The ceiling of the plant should be at least 12 feet high. When the pasteurizing equipment is on the balcony, midway between the ground floor and the second floor, the handling room and the bottling room should be two full stories.

MATERIALS OF CONSTRUCTION.

The materials used for the construction of the plant depend a great deal on local conditions. The most satisfactory materials that may be used are reinforced concrete, hollow tile with cement finish, or selected brick. Cement blocks are also used to a limited extent. When concrete is used, the inside walls should be finished with a smooth surface and protected with paint that will stand hot water and steam.

At present the proportion of brick plants and wooden plants is large, but concrete is becoming very popular in many localities and is probably the most suitable for a milk plant. It is practically fireproof, very sanitary, weather resistant, and durable. Hollow tile with stucco finish is also much used for milk plants. With that type of construction the inside walls must be finished with cement or similar material. In certain localities cement blocks are used. This form of construction is usually found in the smaller plants and is very satisfactory, provided the material is not too expensive. The wood-frame buildings in nearly all cases are old ones. Many plants are now built of selected brick with cement finish on the inside, which is a very satisfactory type of construction.

INSIDE WALLS AND CEILINGS.

For the inside walls select a material that will provide a smooth, easily cleaned surface that is durable and waterproof. Concrete or cement is very commonly used and is quite satisfactory. This ma-

terial can be finished with a smooth surface which is sanitary and can be easily washed with the hose. Walls should be coated with a paint as nearly waterproof and steamproof as possible. When wooden walls or partitions are used, the concrete of the floor should extend about 2 feet up the wall, as that part of the wall is exposed to water a large part of the time.

For inside walls of rooms where milk is handled, enamel brick, tile, enamel cement, or cement plaster is satisfactory. Tile or enamel brick is preferable but rather expensive. The different materials used in 20 plants which had special material for these rooms were as follows: Enamel brick, 12 plants; tile, 4 plants; cement plaster, 1 plant; enamel cement, 3 plants.

All the foregoing materials have a smooth surface and are easily kept clean. They give the room a sanitary appearance and are good reflectors of light. Enamel brick is less expensive than tile and is much used for the walls of milk-handling rooms.

Ceilings are usually constructed of materials similar to those used on the inside walls. The following were found in various plants: Wood, concrete, cement plaster, plaster on lath, and galvanized metal. As in the case of the inside walls, the ceiling should be smooth, durable, easily cleaned, and as nearly waterproof and steamproof as possible.

FLOORS.

Several large plants had wooden floors, but wood is a very poor material for floors where milk is handled. Wood is not durable and the milk soaks into it, causing bad odors and insanitary conditions. If a wooden floor is very tight it may be satisfactory for a short time if it is cleaned often, but its period of usefulness is short. Some form of concrete with a waterproof finish is the most desirable material. Frequently a hardener of steel filings mixed with the cement is used to form the finish, which makes the floor wear better. Sometimes, where an old building is used for a milk plant, a concrete floor may be laid over wood, if the underpinning is strong enough. If properly laid, a concrete floor is smooth and can be easily cleaned with hot water from a hose. Milk does not soak into concrete floors as it does into those of brick or wood. Concrete floors should have a good foundation with at least $3\frac{1}{2}$ inches of concrete below the top surface. Asphalt is sometimes used, but it is not very satisfactory because heat tends to soften it.

A tile floor in the bottle-filling room is desirable. Although more expensive when properly laid, it makes a good appearance, is durable, easily cleaned, and very sanitary.

Iron plates embedded in the cement protect the floor in rooms where cans and trucks are constantly being handled. An unprotected concrete floor wears out quickly if cans are continually rolled over it.

Floors in the milk-handling or washing rooms should have a slope of about one-fourth inch per foot toward the floor drains. Drains should be located when the floor is laid to insure a correct slope of floor and should be trapped and connected with the sewer. They should be from 6 to 8 inches wide and have perforated, removable covers. Great care should be taken in laying the floor to avoid making hollows in which water may collect. Before installing the plumbing it is advisable to be sure that it conforms to local plumbing regulations.

THE COLD-STORAGE ROOM.

The milk-storage or refrigerator room must be well insulated to keep the milk always at low temperature. The most common insulating materials are cork board, mineral wool, vegetable fiber, sawdust, and shavings, which are used as fillers in walls of wood, cement, or masonry. Cement should be put over the insulating material for the inside walls and ceilings to protect that material from moisture. The floors of the refrigerator should be of concrete laid solidly on the insulating material. The most satisfactory construction is about 4 inches of cork-board insulation with cement on the inside and outside.[1] Good drainage to a drain pipe, carefully trapped to prevent warm air from entering the room, is very important.

ARRANGEMENT OF PLANT.

HANDLING THE MILK AT ENTRANCE.

In the arrangement of rooms and machinery, economy of operation as well as sanitation must be considered. In the layout of the plant, provision should be made for the convenient and rapid loading and unloading of wagons. This applies to the delivery wagons and also to the trucks which bring the milk to the plant.

Some plants are so arranged that it is necessary for the trucks to be unloaded inside the building. Such a system is not conducive to rapid unloading. When the trucks drive inside the building there is a smaller space to turn in, and greater danger of contamination from dirt and dust of the street coming in through the open door of the receiving room. The use of a platform on the outside of the plant at the receiving room allows the milk to be handled much more readily. The platform need be only a few feet wide, but there should be ample space for two or more trucks to drive up to the platform at one time.

Upon the arrival of the trucks the milk is unloaded at once and sent to the receiving room, where it is dumped immediately. There is no needless driving and backing, as is the case when the trucks unload in the interior of the plant. If the unloading platform is

[1] For detailed information as to construction of storage rooms, see U. S. Department of Agriculture Bulletin 98.

outside, the truck can be quickly unloaded and another driven up immediately and unloaded. Usually two or more trucks can be unloaded at one time, which is not the case if they are unloaded within the plant.

Some plants with platforms outside greatly expedite the unloading and dumping of the milk by the use of roller conveyers. The platform should be covered to protect the workmen from the weather. The cans as they are removed from the truck are placed on the conveyers, on which they are carried to the dump or weigh tank. The cans may then be rolled on more conveyers to the can washer and thence to the can racks or back to the trucks. If the milk is received in this way the receiving room can be kept cleaner and the work can be done much more economically than if the trucks are driven into the building.

The unloading platform should be as close as possible to the receiving room and should be level with the floor of the truck, so that the cans of milk may be readily rolled from the truck. By having the dump tank close to the receiving platform and also lowered to the level of the floor, milk may be handled rapidly and with few men. It is desirable, however, to have the receiving room well inclosed and far enough from the street to reduce to a minimum the chances of contamination of the milk from that source. At many plants the platform can be most advantageously placed at some distance from the receiving room, even though more time and men may be required to receive and dump the milk. At such plants, much time and labor can usually be saved by the use of conveyers.

The plant should be so arranged that there will be no confusion of the milk trucks with the delivery wagons. A convenient arrangement is to have the receiving platform on one side of the building and the loading platform for delivery wagons on the other side.

In Table 1 a comparison is made of a few plants to illustrate three methods of arrangement for receiving the milk.

TABLE 1.—*Economy of various arrangements of plants for receiving and dumping milk.*

Type of plant.	Number of plants.	Average number of cans received per plant.	Average number of men per plant.	Average time per plant.	Average hours of labor per plant.[1]	Average hours of labor per 100 cans.	Average time per 100 cans.	Average cans handled per hour.
				Hours.			*Hours.*	
Truck unloaded inside plant and milk either dumped at ground floor or sent upstairs on elevators (no platforms used)	3	207	3.3	2.5	8.3	4.0	1.2	82.6
Trucks unloaded at platform and milk sent to receiving room on conveyers	3	643	4	4	19.0	2.9	.8	121
Trucks unloaded at platform and milk dumped in tank near by	2	500	2.5	3.2	8.7	1.7	.65	154

[1] "Man hours."

When the trucks were unloaded inside of a building that has no platform, considerably more time and labor were required to handle 100 cans of milk. The system of using conveyers to send the milk from the platform to the receiving room required more men and time than when the milk was dumped direct without the use of conveyers. This is due to the fact that at the plants where no conveyers were used the dumping tank was quite close to the receiving platform and less handling was required. The dump tanks at these plants were also sunk in the floor, so that very little lifting of the cans was required. In the plants where the conveyers were used the receiving room was much better protected from contamination, being further from the receiving platform and better inclosed. If conveyers had not

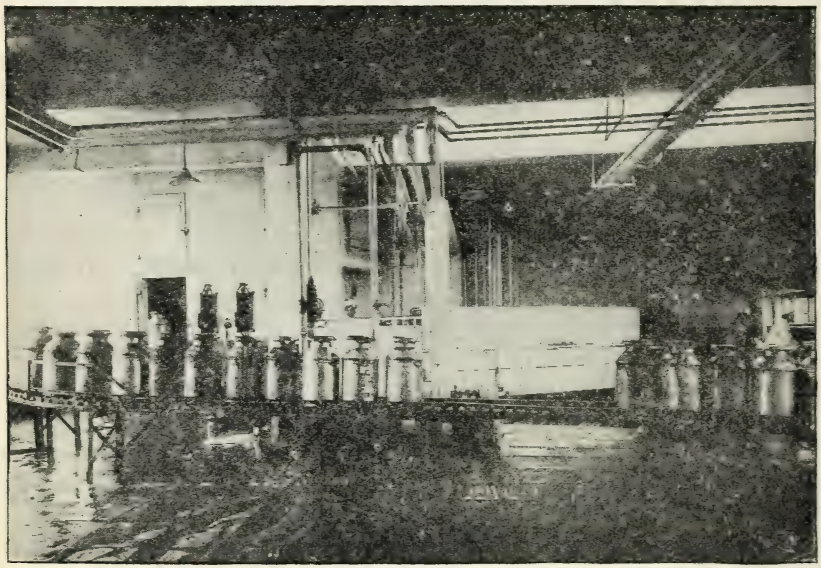

FIG. 3.—System of conveying cans and milk from the trucks to the dump tank, located at a considerable distance from the entrance to the receiving room.

been used at these plants more men would have been required. The necessity for a conveyer depends, of course, on the location of the dump tank with reference to the receiving platform.

MILK PUMPS COMPARED WITH ELEVATORS.

Very few plants elevated the milk to the top floor in the cans, the majority using pumps. Studies were made at 28 typical plants to determine the relative economy of the systems of (*A*) dumping the milk in tanks on the ground floor and then pumping from this tank to the receiving tank above, (*B*) raising the milk in cans to the top floor by means of power conveyers, and (*C*) raising the cans of milk by means of freight elevators. If conveyers are used trouble is sometimes experienced by a can being improperly placed on the apparatus

and the milk spilled. A comparison of the economy of the three systems is shown in Table 2.

TABLE 2.—*Comparison of men and time required to receive and dump the milk and wash the cans at three different types of plants.*

Type of plant.	Number of plants.	Average cans of milk per plant.	Average time spent per plant.	Average number of men per plant.	Average hours of labor per plant.	Average hours of labor per 100 cans received.	Average time per 100 cans received.	Average cans received and dumped per hour.
			Hours.				*Hours.*	
A (pump)	18	1,034.7	4.9	4.3	26.2	2.5	0.47	212.6
B (conveyer)	6	845	4.9	5.7	30.8	3.6	.58	172.0
C (elevator)	4	825	8.1	5.8	58.4	7.1	.99	101.5

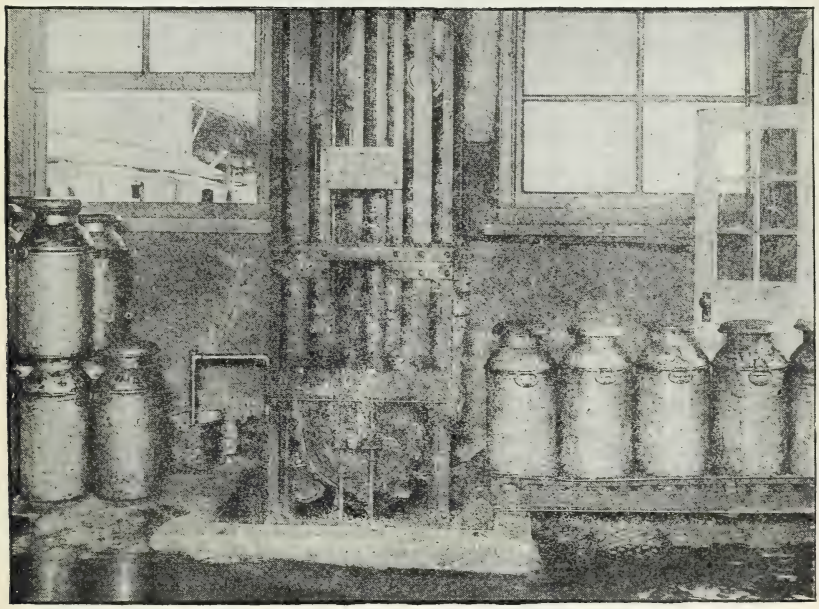

FIG. 4.—Gravity conveyers bringing cans of milk from trucks to power conveyer, which carries them to top floor where milk is dumped.

From the data in this table it is apparent that the system of pumping the milk from the ground floor rather than elevating it in cans is much more economical in the use of labor. At these plants the pumping system was more than twice as efficient as the elevator and much more efficient than the conveyer system. The conveyer system, however, is more economical in the use of labor than the elevator system and requires only about one-half as many man hours to handle 100 cans of milk. Of course, other factors enter into this problem, but these figures will illustrate the general tendency.

In some plants it may be necessary to have the receiving room on the top floor because of lack of space on the ground floor, but that is

an arrangement to be avoided. Of course in plants where the number of cans handled is small, the element of time spent in receiving the milk is of less importance and conveyers or even elevators are often satisfactory.

LOADING DELIVERY WAGONS.

A study was made at several typical plants using different systems of loading delivery wagons, and the data obtained are shown in Table 3. The various systems studied were: (*A*) Wagons loaded in the interior of the building (milk trucked from storage room, no

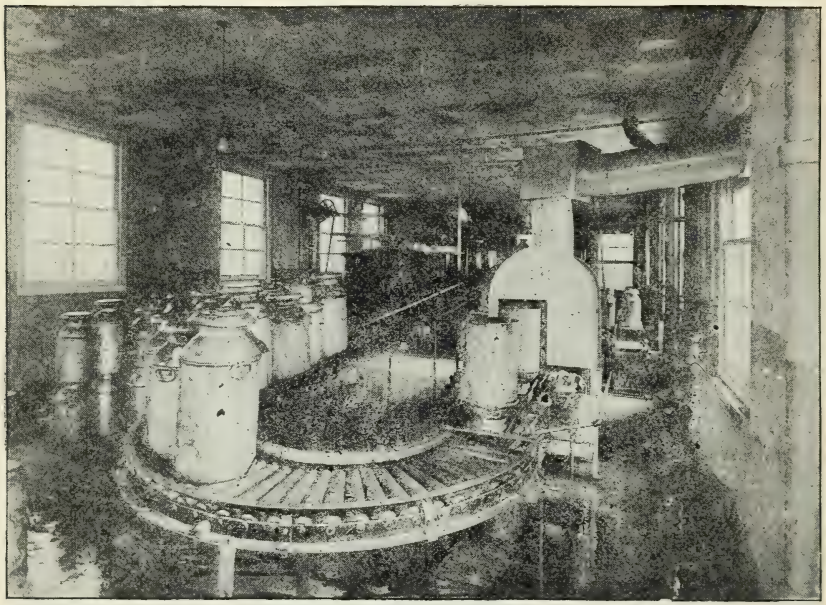

FIG. 5.—Dumping milk into weigh can from which it goes to glass-lined storage tank. Note gravity conveyers used to convey the empty cans from the dump tank to the can washer and then to carrier which conveys the clean cans down to the trucks. This system of receiving milk was much more economical as to time and labor required than the system of using freight elevators, but not so economical as the system of dumping the milk at the ground floor and pumping it and washing the cans downstairs.

platform); (*B*) wagons loaded from exterior platform (milk trucked from storage room); (*C*) wagons loaded from exterior platform (milk sent on conveyers from storage room to loading platform); (*D*) wagons loaded direct from storage room, one small door or chute being used; (E) wagons loaded direct from storage room, 2 doors or chutes being used; (*F*) same as *E*, except that 3 doors are used; (*G*) same as *E*, except that 4 or more doors are used.

The driver is included in all cases under "Average number men per plant." From the column "Average hours of labor per wagon" in Table 3 it will be seen that the time is greatest when milk is loaded inside the building, and that fewest hours of labor are re-

quired to handle milk loaded direct from storage room through two or more loading openings. In view of current labor costs this is a highly important point to consider in deciding on the arrangement of a milk plant. The cost of construction is an expense to be met only once, whereas the expense of labor is continuous.

TABLE 3.—*Comparison of time and men required to load delivery wagons at plants using various systems of loading.*

System of loading.	Number of plants.	Number of wagons loaded daily per plant.		Average number men per plant.	Average hours of labor per plant.	Average hours of labor per wagon.	Average time per plant.	Average time per wagon.	Average number wagons loaded per hour.
		Average.	Variation.						
							Minutes.	*Minutes.*	
A (inside building)	1	22	.....	4	16	0.73	210	10.9	5.5
B (exterior platform trucks)	4	36.5	21–73	3.2	21.11	.58	314	8.6	7
C (exterior platform conveyers)	3	52.6	10–80	6	22.2	.42	180	3.4	17.7
D (direct from storage—1 door or chute)	1	16	.....	3	7.5	.47	150	9.4	6.4
E (direct from storage—2 doors or chutes)	3	91	78–100	8	21.5	.23	160	1.75	34.3
F (direct from storage—3 doors or chutes)	6	75	50–130	5.3	14.5	.19	150	2	30
G (direct from storage—4 or more doors or chutes)	2	105.5	80–131	6.5	16.3	.15	160	1.4	42.9

It will be noted that there is a slightly less regular decrease in respect to "Average time per wagon," the size of the plant being a very important consideration in this problem. The sizes of the plants studied are indicated under "Average number wagons loaded per plant." System *G* would be practicable for only the larger-sized plants, while systems *E* and *F* would be impracticable for small plants. More men are usually required with systems *E*, *F*, and *G* than with systems *A*, *B*, and *D*.

It is usually desirable to load all the wagons within two or three hours if possible. The data in the table seem to indicate that when 75 to 100 or more wagons are to be loaded in this time either a conveyer system or a system of loading direct from the storage room through two or more doors or chutes is essential. While with these systems more men are required, the time per wagon loaded as well as the "Average hours of labor per wagon" loaded is considerably less than with the other methods, and the time element is very important where a considerable number of wagons are to be loaded.

These points illustrate the inefficiency of loading wagons within the plant and without having a platform. The milk must be brought from the storage room on hand trucks and each case of milk must be lifted from the trucks to the wagon. If the wagons are loaded from

a platform or from chutes which are placed so high that they come even with the floor of the delivery wagon, very little lifting is required.

The figures in Table 3 also indicate that if a platform is used the system of trucking the milk from the storage room is much less economical as to time and labor than sending the milk out on conveyers. At a small plant loading only a few wagons the use of conveyers may not be practicable. One or two men besides the driver can handle the work, while in using a conveyer system more men may be necessary, although the time consumed would be less.

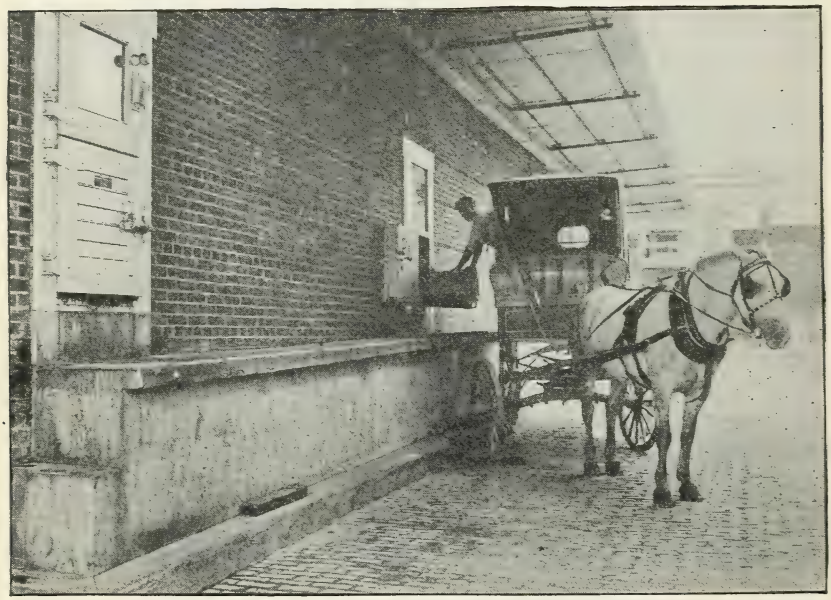

FIG. 6.—Loading delivery wagons at plant using system *E*. (The second chute was not in use at the time the photograph was taken.) An average of 34.3 wagons per hour were loaded at the three plants using this system. The average time required to load one wagon varied from 1.5 to 2.3 minutes.

The table also indicates that considerable time may be saved by using a conveyer rather than by loading the wagons direct from the storage room through one door or chute; though this means but little if only a few wagons are to be loaded. The hours of labor per wagon were not very different with the two systems, while the time per wagon was nearly three times as great with system *D* as with the platform-and-conveyer system.

At plants where two or more chutes from the refrigerator room are used, roller conveyers generally carry the milk from the rear of the room to the door, and usually one class of goods is put out at each door. For example, quarts of milk will be put out at door No. 1, pints at No. 2, and cream, etc., at door No. 3. As many wagons can

be loaded at one time as there are doors. Thus the wagons are loaded in rapid succession and only slightly more than a minute (average) per wagon is required at some plants having three or more doors. When only one door is used more time is required per wagon. Where an exterior platform is used, whether the milk is conveyed from the storage room or trucked, usually two or more wagons may be loaded at the same time.

UNLOADING DELIVERY WAGONS.

Three systems of unloading the "returns" from the wagons returning from the routes are shown in Table 4.

TABLE 4.—*Time and men required to unload delivery wagons ("returns") at various plants using different systems.*

Type of plant.	Number of plants.	Average number of wagons per plant.	Average number of men per plant.	Average time per plant.	Average hours of labor per plant.	Average hours of labor per wagon.	Average time per wagon.	Wagons unloaded per hour.
				Minutes.			*Minutes.*	
A. Conveyer system (power or gravity)	8	88.4	3.7	177	11.2	0.13	2	30.0
B. Wagons unloaded on platform; then hand trucks.	3	57.6	2.6	240	11.5	.20	4.2	14.4
C. Wagons unloaded in interior of plant and hand trucks used	2	21	2	127	4.25	.20	6.1	9.9

It will be noted that for plants with a large number of wagons considerable time may be saved by using conveyers, as shown under system *A*, and that much time may be wasted by unloading the wagons within the plant. When a platform is used several wagons may be unloaded at one time, and when conveyers are used the driver simply throws his load on to the conveyer, and in this way the work is done at a rapid rate.

DIVISION OF ROOMS.

For economy of operation and sanitation, a division of rooms is essential in the modern milk plant. In many small plants the greater part of the work is done in one room, but in the larger and more modern plants a special room is provided for each operation. Each room should be laid out and constructed for the particular purpose for which it is designed.

In the receiving room the milk is inspected, sampled, and weighed. This room contains the weigh tank, scales, and milk-sampling outfit, and should be screened and separate from the other parts of the plant. After the cans are dumped they are drained, washed, sterilized, and returned. The can-washing apparatus should be located either in the receiving room or in a room adjoining it.

Handling room.—From the receiving room the milk goes to the pasteurizing rooms, where it is pasteurized and cooled before going to the bottling room. The latter room contains the fillers and cappers and should be well lighted, ventilated, and entirely sanitary. This is the room that attracts the attention of visitors. The bottles are inspected there for the last time and plenty of light is essential. In some plants this room is separate, while in others the pasteurizing and bottling are done in the same room. Usually the pasteurizing vats are upon a half or mezzanine floor. It is important to have this milk-handling room separate from other rooms in the plant.

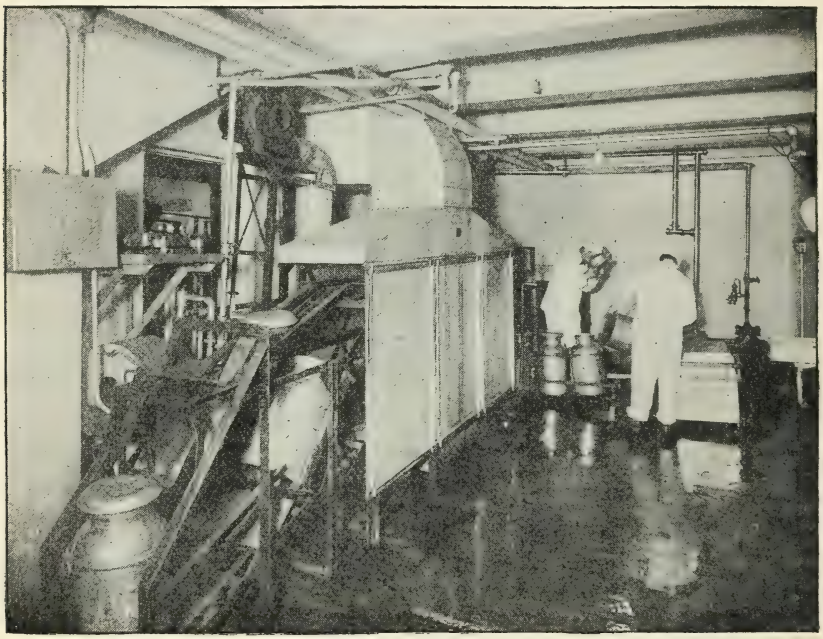

FIG. 7.—Receiving room with can washer.

Bottle-washing room.—This room should be separate so that no steam or foul air can pass into the rooms where milk is handled.

Clean-bottle storage room.—Between the bottle-washing room and the filling room many plants have a clean-bottle storage room where bottles are stored after being washed. This room must be cool and kept strictly clean, so that the bottles can cool and be kept free from dust or dirt. To obtain the best results, the air in the bottle-storage room is washed and artificially cooled.

Milk-storage room.—A well-insulated cold-storage room is necessary to keep the milk cold after it is put into bottles. The construction of cold-storage rooms is discussed on pages 12 and 24.

Salesroom.—The salesroom at the front of the building should be attractive in appearance and should contain a counter, a refrigerator, and perhaps a few chairs and tables for customers.

Drivers' room.—A room connected with the office should be provided in which drivers can score their books on returning from the routes. Bath and toilet facilities also should be provided for the drivers and men.

Laboratory.—A laboratory for the bacteriological and chemical examination of milk is essential for all plants. Small plants need only a small laboratory, while large ones require a complete laboratory with a full supply of chemical and bacteriological equipment.

By-products room.—Space should be provided for handling by-products. Small plants require space for making only small quantities of butter, cottage cheese, and buttermilk, which sometimes may

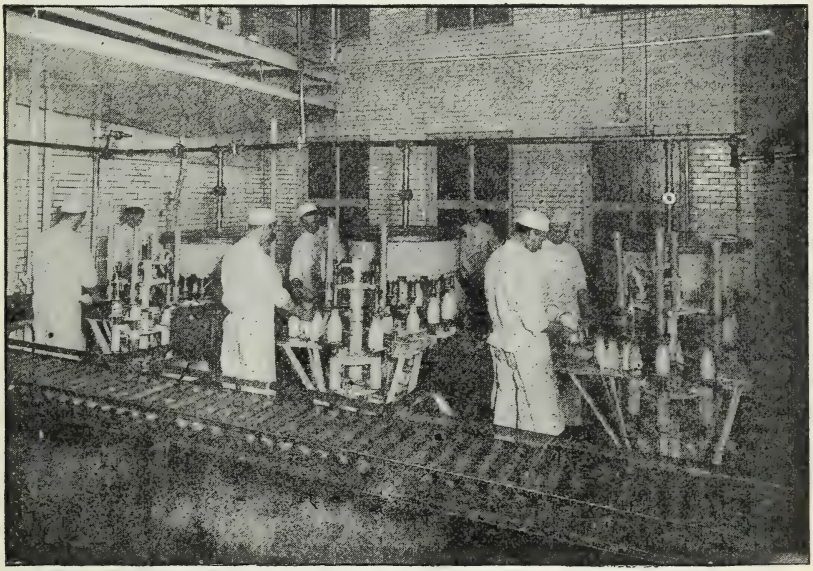

FIG. 8.—Filling and capping department. The bottles, after being filled and put in the cases, are sent on gravity conveyers to the milk-storage room.

be done in the milk-handling room. In medium-sized or large plants, however, one or more separate rooms are required for the by-products department.

SIZE OF ROOMS.

Each room in the plant should be large enough to avoid crowding the machinery or workmen, but at the same time there should be no unused space, for that causes extra labor in getting from one piece of apparatus to another.

There is a wide variation in the size of the various rooms in milk plants, as well as in floor area per 100 gallons of bottled milk handled daily. These variations are due in a large measure to the lack of standardization of milk plants and to the fact that many have been constructed without consideration of important factors bearing on the size of rooms.

Measurements from 5 modern, well-arranged plants that were built after careful study as to size of rooms are shown in Table 5. These plants were built in recent years and are giving satisfaction in regard to arrangement of rooms and machinery. The figures given illustrate the size of rooms that give satisfaction in modern plants.

It is important that the receiving room be of ample size. A small receiving room soon becomes crowded and "cluttered up" and is difficult to keep clean and attractive. There should be room enough to hold conveniently one or more truck loads of milk in cans and to

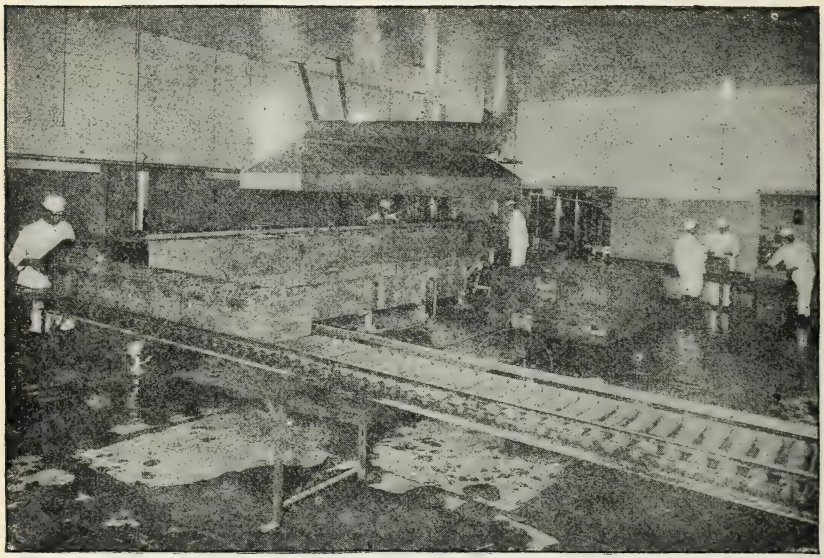

FIG. 9.—Bottle-washing room. Note use of gravity conveyers.

have plenty of room to handle the milk without crowding. It often happens that several loads of milk may arrive within a short space

TABLE 5.—*Floor space in various rooms of 5 well-arranged plants of various sizes.*

Quantity of bottled milk handled daily.	Receiving room.	Bottle-washing room.	Pasteurizing room.	Bottling room.	Total area for receiving, washing, pasteurizing, and bottling rooms.	Milk-storage room.	Clean-bottle storage room.
Gallons.	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*	*Sq. ft.*
1,000	400	600	500	300	1,800	450	400
1,500	.....	700	550	375	1,625	550	.....
3,000	900	1,050	1,300	1,200	4,450	1,200	750
4,000	460	1,886	540	700	3,586	1,426	540
6,000	1,200	1,908	720	720	4,548	1,110	720

of time and unless there are storage tanks it will have to remain in the cans in the receiving room until it can be dumped.

The size of the bottle-washing room depends somewhat on how the bottles are handled as they come from the delivery wagons. In case they have to be stacked in the wash room before being washed, a larger room will be required than if they pass directly from the delivery wagons to the washing machine and then on to the clean-bottle storeroom or the filling room. In case they do not have to be stacked, about all the space necessary is that required for the bottle-washing machine and ample room for the workmen to get around the machine. If the milk cans are washed in this room, additional space will be required.

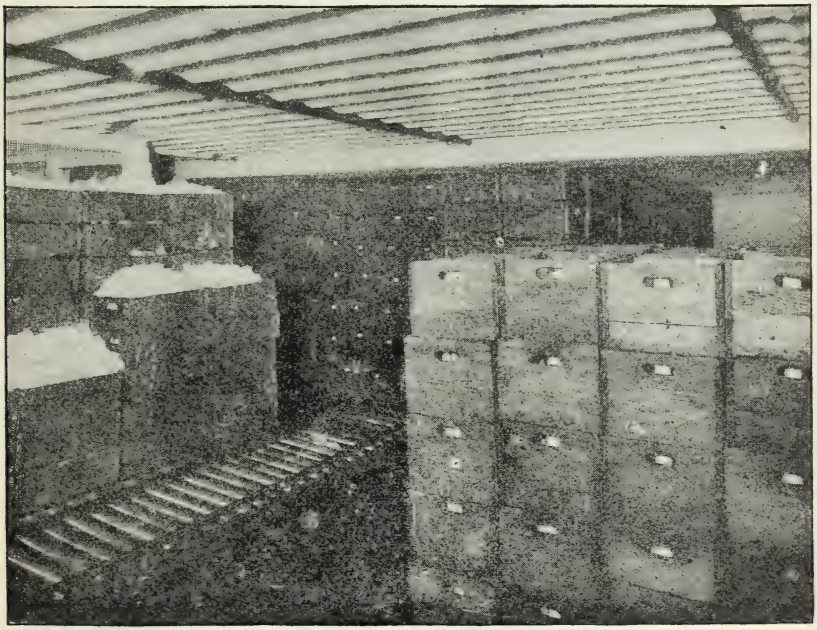

FIG. 10.—Milk-storage room using direct system of cooling with cooling coils overhead. Note iron plates in floor.

The clean-bottle storage room should be large enough to accommodate conveniently at least all the bottles handled in one day. If it is desired to store more than a day's supply of bottles at one time, the room necessarily would have to be larger.

The pasteurizing room should be sufficiently large to contain the milk vats, clarifier, and pasteurizing equipment and still leave plenty of room for the men to work and to get around the machines for the daily cleaning. At some plants proper cleaning is often neglected because the men do not have space enough in which to work.

The bottle-filling room may be smaller than the other rooms, because usually the bottles pass continuously through it. When there

is no clean-bottle storage room, however, the bottle-filling room will have to be big enough to store the clean bottles. It should also be large enough to allow plenty of room for the men to get around the filling machines for operating and cleaning.

The milk-storage room must be of sufficient size to hold all the milk that is to be handled, with space to spare for an emergency. Space should be allowed for a passageway between the tiers of various kinds of goods, such as pints and quarts of milk and jars of cream. Too large a room, however, is wasteful and requires additional refrigeration. The ceiling need not be more than 8 or 10 feet high after allowing for brine tank or pipes. A room 15 by 16 feet provides a space of 240 square feet. If cases of quarts are piled 6 high and pints 7 high, the space would provide for about 2,000 gallons of bottled milk in cases. Allowing space for the men to work and for emergencies, a room about 18 by 20 feet should be provided for 2,000 gallons of milk in bottles. A room 12 by 15 feet would provide space for about 1,000 gallons of bottled milk. In order to economize on refrigeration and insulating material the room should be as nearly square as possible. The proportion of milk that has to be held over in storage is one of the causes of the variation in size of storage rooms, as some plants send milk out on delivery wagons immediately after bottling without going to the storage room. When large quantities of milk are stored in cans more space is required, as cans of milk can not be packed so closely or so high as milk in cases of bottles.

The size of the by-products room depends upon the type of business conducted, but ample space must be provided for the churn, cheese vats, and similar equipment, with plenty of room for the men to work.

ARRANGEMENT OF ROOMS.

The rooms in the plant should be arranged so as to necessitate a minimum expenditure for machinery and labor; they should be so laid out that the work can be carried on with the fewest possible steps. It is desirable that the bottle-washing room, for example, be handy to both the boiler room and bottle-filling room. In this way little steam is lost in transferring it from the boiler to the washing room and the washed bottles are readily transferred to the filling room.

The bottle-washing room should also be so situated that the returned bottles may pass directly from the receiving platform to the washing machines. In some plants the bottle-washing room is directly under or over the filling room, which may be convenient where there are facilities for elevating or lowering the bottles. If there is space enough, however, it is generally more convenient to have the washroom and the bottle-filling room on the first floor.

The location of the cold-storage room depends on various considerations, but if possible it should be situated so that the milk can go directly into it from the bottling room. It should also be accessible to the delivery wagons, so that they can be easily and quickly loaded. To save refrigeration only a minimum wall surface of the refrigerator should be exposed to outside air or sun. Usually windows are unnecessary in the refrigerator. If there are windows they should have three or more thicknesses of glass with spaces between, and the glass should be covered with white paint to exclude the direct rays of the sun. When not needed all artificial lights should be extinguished, as they increase the room temperature.

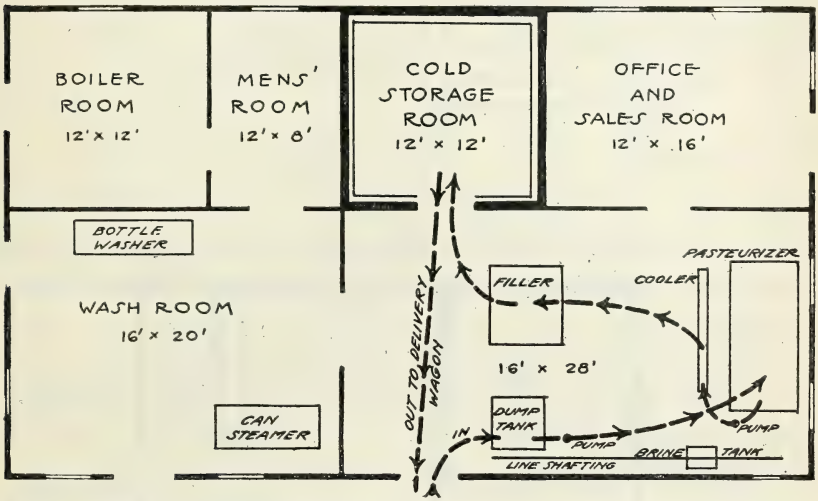

FIG. 11.—Floor plan for a 1-story plant of about 500 gallons' daily capacity, showing course of milk through plant.

The doors of the refrigerator room should fit tightly, swing outward, and be adapted to quick handling. Doors swinging inward reduce the storage space considerably. A vestibule to the refrigerator room, while taking up some extra space, prevents a considerable loss of refrigeration.

ARRANGEMENT OF EQUIPMENT AND MACHINERY.

Equipment should be arranged to permit easy cleaning. In some plants tanks are so placed that the man who cleans them has to squeeze in between the top of the tanks and the ceiling in order to reach them. Much time is saved by convenient arrangement and the cleaner will be less liable to neglect the work.

Machinery should be placed so as to minimize labor requirements and to use space most economically. Another point to be considered in placing the machinery is the reduction to a minimum of conveyers, pumps, pipes, and fittings. This applies not only to milk piping but

also to water and steam piping. Large quantities of piping and fittings are expensive, cause extra labor, and in the case of milk pipes may be insanitary. The course of the milk through the plant should be as direct as possible from the receiving tank, through the clarifier, pasteurizer, and bottling machines to the cold-storage room. Mechanical conveyers should be used whenever labor and time can be saved; otherwise the extra expense incident to their use is not warranted.

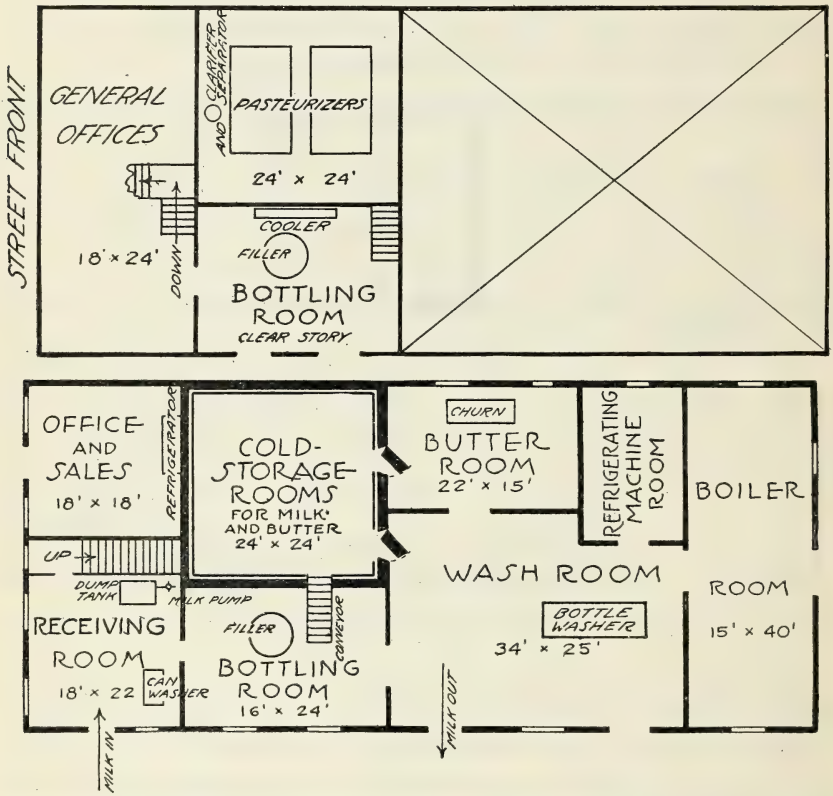

FIG. 12.—Floor plans for a 1½-story plant of from 1,500 to 2,000 gallons' daily capacity, where butter also is handled.

At 73 plants the number of milk pumps used varied from none to 4, and the milk piping used from none to 300 feet. A wide range occurred in plants in the same class, as well as in plants of the same size. For example, at 26 plants of class 4 the length of milk piping varied from 20 to 210 feet, and the number of milk pumps varied from 2 to 4, and at 20 plants handling from 2,001 to 5,000 gallons daily the length of the milk piping varied from 30 to 300 feet and the number of milk pumps from none to 4.

Great lengths of milk piping cause extra labor and expense and tend to increase the loss of milk both from milk sticking to the sides

of the pipes and from leaks at joints. If piping must be used, it should be of simple and sanitary construction, with frequent unions to permit thorough cleaning and sterilizing after each use. It is important to have all turns in the pipes easily accessible and easily cleaned. Elbows and tees are to be avoided as much as possible, but when they are used, openings at the end will facilitate cleaning. A right-angle bend may be used if there is space, for in this fitting there are no recesses in which dirt can collect. When such joints are used the piping may be more easily kept clean.

The pumps as well as the pipes should be cleaned and sterilized each time after using. It is less objectionable to use milk pumps before pasteurizing than after, for milk pumped after pasteurization may be recontaminated if the pump is not clean, and the added agitation may injure the cream line. Pumps should be of sanitary construction and of sufficient capacity to do the work without being overtaxed.

EFFECT OF ARRANGEMENT OF PLANT ON LABOR REQUIREMENTS.

The number of employees required to carry on the various operations in the plant depends to a large degree on the layout and size of rooms, arrangement of machinery, and size and type of building. Table 6 shows the number of men employed at 157 plants of various sizes. They include only those in the plant and in the boiler and engine rooms. In plants where ice cream is handled the time of the men in the power plant was prorated according to the quantities handled, and where there was a separate butter department the men who put all their time in that department were not included. The figures given do not necessarily indicate the total number of men employed at one plant, but one man indicates a full day for one man, as, for example, when the average number of employees is given as one, it may indicate that one man spends one-half of his time and two others one-fourth of their time each in the plant.

TABLE 6.—*Number of men employed in city milk plants of various sizes (men inside the plant only).*

Capacity of plant.	Number of plants.	Quantity of milk handled daily.		Employees in plant.			Employees in plant per 100 gallons handled. Average.
		Total.	Average.	Total.	Average.	Variation.	
Gallons.		*Gallons.*	*Gallons.*				
Up to 100	4	250	63	4.3	1.1	1 to 1.3	1.7
101 to 250	19	3,285	173	32.5	1.7	1 to 3	1.0
251 to 500	31	12,435	401	86.5	2.8	1.5 to 6	.7
501 to 1,000	34	26,885	790	193.0	5.7	2 to 13	.7
1,001 to 1,500	16	20,750	1,297	114.5	7.2	2.5 to 17	.6
1,501 to 2,000	11	19,600	1,782	126.0	11.5	6 to 21	.6
2,001 to 3,000	13	34,450	2,650	190.0	14.6	8 to 27	.6
3,001 to 5,000	16	64,650	4,041	328.0	20.5	7 to 36	.5
5,001 to 10,000	9	66,700	7,411	294.0	32.7	9 to 49	.4
Over 10,000	4	69,000	17,250	343.0	85.8	49 to 100	.5
Total or average	157	317,975	2,025	1,711.8	10.9	1 to 100	.5

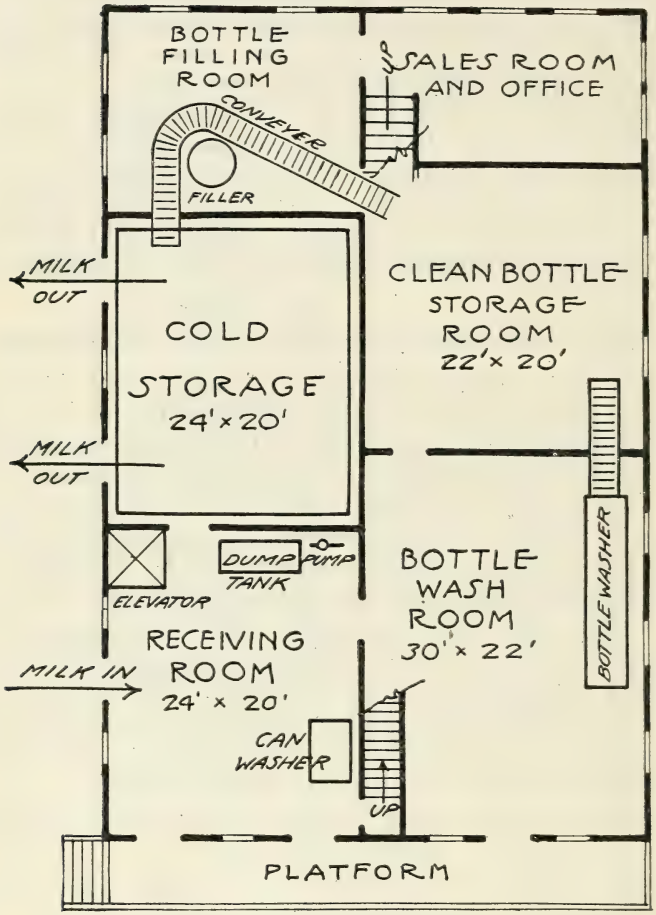

FIG. 13.—First-floor plan of a two-story plant of from 2,000 to 3,000 gallons' daily capacity.

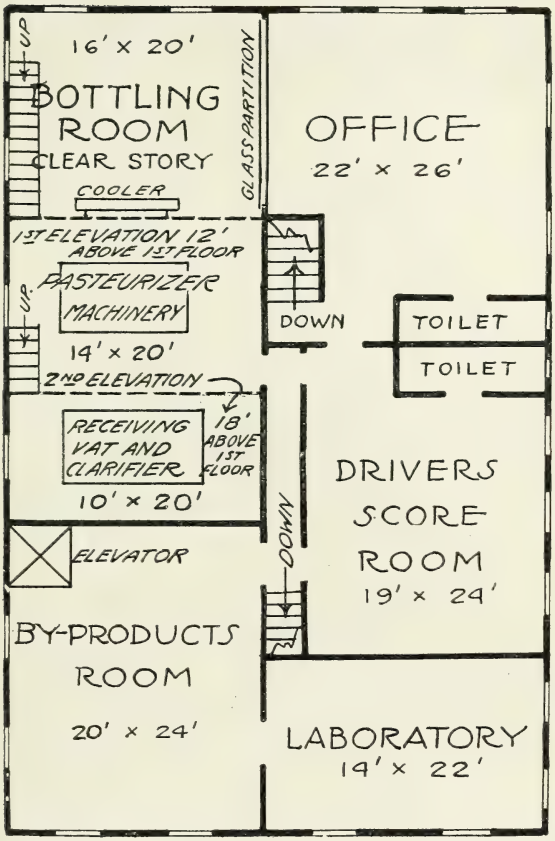

FIG. 13A.—Second-floor plan for a two-story plant of from 2,000 to 3,000 gallons' daily capacity.

NOTE.—Blue prints showing approved plans for milk plants of various sizes and arrangements may be obtained free on request, by those contemplating the erection of such plants, from the Dairy Division, U. S. Department of Agriculture, Washington, D. C.

The average number of men in each plant bears a very close relation to the quantity of milk handled. It will be noted, however, that there is a wide variation in the number of men employed at the various plants in each group. Some plants employ six times as many men as others of the same size. Although some other factors are involved, such as the relative quantities of bottled milk handled, these figures effectually illustrate the fact that some plants are not operated so efficiently as others, which is due, to a great extent, to the faulty layout and arrangement of rooms and machinery. Many plants could cut down their labor by a more economical layout of machinery and equipment, while others could reduce it by installing more labor-saving machinery. Some plants have too many floors or stories to be able to utilize labor efficiently. For example, it is often necessary to have a set of men with a foreman on each floor. It can be readily seen that a plant with four or five floors requires more men and can utilize labor less efficiently than a plant handling the same quantity of milk with only one or two floors, although the latter plant may have nearly as much floor space as the larger building. The gravity system of milk handling (which is now generally recognized as the most efficient) can be used as well in a plant of 2½ stories as in one of 4 or 5 stories. By having the pasteurizing equipment on a mezzanine floor, practically all the milk handling can be done in one room; the gravity system of handling can be used and the number of men can be reduced to a minimum.

SANITARY REQUIREMENTS.

WATER SUPPLY.

An abundant supply of water should be available at the plant at all times. Large quantities of water are required for pasteurizing and cooling, for boilers and refrigerating machinery, and also for washing purposes. The quantity required for washing bottles and cans and cleaning up milk apparatus is considerable, and, besides, there are the requirements necessary for keeping the floors and walls well washed. Table 7 gives the quantity of water used at several plants of various sizes.

TABLE 7.—*Quantity of water used at milk plants of various sizes.*

Capacity of plant (gallons).	Average quantity of milk handled daily.	Quantity of water used daily.		Quantity of water used daily per 100 gallons milk handled.	
		Average.	Variation.	Average.	Variation.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Up to 1,000	500	4,800	(1)	960	(1)
1,001 to 2,000	1,566	14,255	11,000 to 18,300	909	520 to 1,220.
2,001 to 3,000	2,692	11,722	6,710 to 17,235	436	287 to 580.
3,001 to 5,000	3,500	17,735	3,070 to 32,400	509	77 to 1,080.
5,001 to 10,000	6,788	16,135	(1)	238	(1)
Over 10,000	15,999	112,007	102,000 to 122,015	700	611 to 850.

[1] Only 1 plant in group.

STEAM.

It is important that all milk-handling equipment be sterilized immediately after washing, and plenty of live steam must be available. A convenient arrangement is to have a valve connected with the city water and with the steam system. By the use of such connection either hot or cold water or steam is made available. (Hot water can be obtained by turning on both the water and steam valves.)

VENTILATION.

Good ventilation is essential in a milk plant in order to get rid of the bad air and moisture and to insure pure air. In many plants the ventilation is inadequate, often being obtained by means of windows and doors only. It is difficult to get good ventilation by this method. Even in a medium-sized plant exhaust fans should be used to take out the bad air and moisture. Many modern plants have an artificial system of ventilation by which air as pure as can be obtained is drawn through a filter or through a spray of water and then forced by fans through flues into the rooms. The openings from these flues or ducts into the rooms may be near the ceiling or near the floor, but usually they are about midway between. By heating or cooling the spray of water the temperature of the air in the rooms may be controlled to a certain extent.

In large plants the process of filtering air consists in forcing it through one or more thicknesses of cheesecloth, or cloth and absorbent cotton. The air is forced into the room through the filter under a small pressure, so that the used air has a tendency to pass outward through the openings near the ceiling provided for outgoing air. All air coming into the room must pass through the filter, which should be changed often. At some plants before the air is forced into the rooms it is cooled in summer by passing over brine coils and warmed in winter by passing over steam coils.

For a medium or small plant there should be some system of artificial ventilation. A flue system similar to that used in dairy barns is quite efficient and is not expensive. By simply installing outlet flues through which the air can pass out and allowing air to come in through the windows, fairly good ventilation can be obtained.

In many plants the cold-storage room is very poorly ventilated. It is, of course, impracticable to have open windows in this room; consequently if an artificial system of ventilation is not used the ventilation is poor and the best results are not obtained from the cooling coils. There is also a condensation of moisture on the ceiling and a constant dripping, which is very uncomfortable and insanitary.

In plants where artificial ventilation is impracticable considerable improvement can sometimes be made by using an ordinary electric

fan, which will keep the air in circulation and produce better results from the cooling coils.

A considerable number of modern plants have an indirect method of cooling the cold-storage room which also serves as a ventilating system. The air is blown over bunkers or refrigerating coils in another room and then through flues into the cold room. The cold air drops as soon as it reaches the openings in this room and the warmer air passes out through other openings and is again drawn over the refrigerating coils, so that a constant circulation of clean, dry, cold air is maintained.

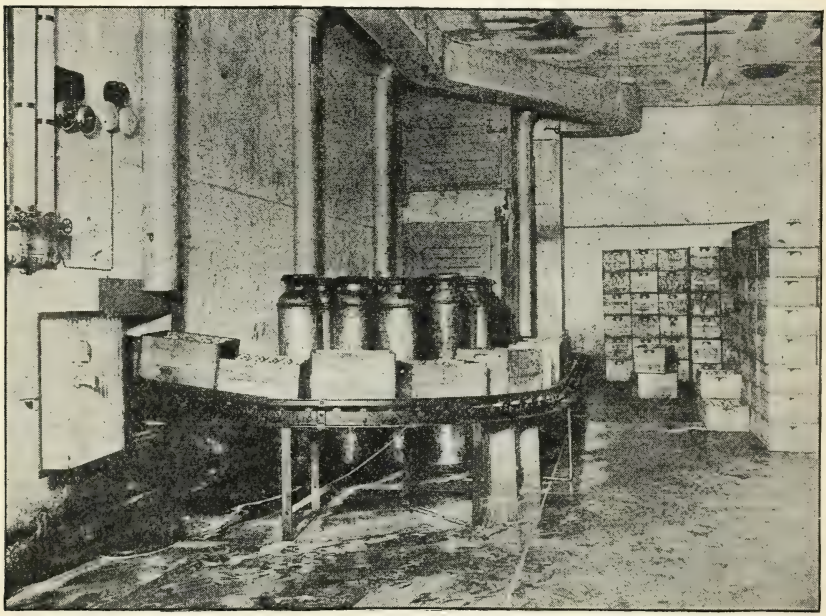

FIG. 14.—Milk-storage room with indirect system of cooling. Note flues through which the cold air is fanned into the room, also system of conveying the milk into the room from the bottling room.

MISCELLANEOUS REQUIREMENTS.

Screens should be attached to all windows and doors during the fly season. The screens should be outside and open outward. The receiving room especially should be well closed in and screened, and self-closing doors should be attached to the room as well as to others through which workmen pass continually. Electric fans will also aid in keeping flies away from the milk and equipment. Double doors at the entrance of the plant with fans blowing toward them will greatly aid in keeping the flies out.

It is important to have a special room for the drivers and other employees. In this room a locker for each man's working clothes is essential, and shower baths and toilet facilities should be provided in an adjoining room.

The milk plant frequently can operate a laundry to advantage, especially if the men's white working suits are washed by the plant. If cleaned at the milk plant's expense the men will be more likely to change them often.

Aside from the general toilet facilities it is advisable to have a washbowl, with soap and towels handy, in the milk-handling room. Employees in the handling room often get their hands dirty from setting up machinery, handling bottles, cases, etc., and it is essential to have a convenient place for them to wash their hands before handling sterilized bottles or engaging in other operations concerning milk.

Milk apparatus should be covered so as to expose the milk to air as little as possible. This caution refers especially to vats, coolers, and bottling machines.

Those dealers who have a business large enough to warrant the maintenance of a laboratory for the careful supervision of the quality of milk are in a much better position to safeguard the milk which goes out from their plants.

COST OF PLANT.

The amount of money that must be invested in a milk plant depends primarily upon the volume of business to be carried on. Whether it is desirable to erect an expensive building depends on local conditions. To give some idea of the cost, Table 8 has been compiled to show the investment in building at 84 representative milk plants of different sizes. In some cases if sufficient capital is not available it may be desirable to rent a building for a time rather than build a new plant, but if a new one is built it is advisable to erect a permanent, sanitary building of modern construction. While the first cost may be high, the permanent nature of the building will make the actual overhead expense for depreciation relatively small.

TABLE 8.—*Investment in buildings for milk plants of various sizes; stables or garages for delivery equipment not included.*[1]

Size of plant (gallons).	Number of plants.	Milk handled daily.		Investment in milk plant.		Investment per 100 gallons handled daily.	
		Total.	Average.	Total.	Average.	Average.	Variation.
		Gallons.	*Gallons.*				
100 or less	5	430	86	$9,000	$1,800	$2,093	$1,000 to $7,143
101 to 250	9	1,935	215	18,000	2,000	930	217 to 3,000
251 to 500	23	9,065	394	86,900	3,778	958	200 to 6,000
501 to 1,000	14	10,655	761	110,335	7,881	1,036	200 to 2,063
1,001 to 1,500	10	13,040	1,304	142,546	14,254	1,093	333 to 2,917
1,501 to 2,000	5	9,200	1,840	116,000	23,200	1,261	250 to 2,000
2,001 to 3,000	4	10,383	2,596	127,074	31,768	1,224	126 to 2,252
3,001 to 5,000	8	33,350	4,169	436,763	54,595	1,309	268 to 2,000
5,001 to 10,000	3	26,000	8,666	450,000	150,000	1,731	1,250 to 2,500
Over 10,000	3	39,000	13,000	534,775	178,258	1,371	1,233 to 1,500
Total or average	84	153,058	1,822	2,031,393	24,183	1,327	126 to 7,143

[1] These figures are based on conditions in 1916–17.

Great variations in investments in plants of the same group were noted. In the group handling from 251 to 500 gallons of milk daily this variation was from $600 to $10,000. The wide variation was largely due to the fact that some of the plants were old wooden buildings not at all suitable for the purpose, while others were modern buildings of permanent construction and in some cases much more expensive than was necessary.

It will be seen in Table 8 that while the average investment is directly proportional to the quantity of milk handled, the average investment per 100 gallons handled daily varies considerably. This investment is the highest for plants handling less than 100 gallons. Plants of that size usually have a relatively high overhead expense on account of the investment in buildings, except when cheap or temporary buildings are used.

Plants handling from 101 to 250 gallons daily had an average investment of only $200 higher than plants handling 100 gallons or less and also had the lowest investment per 100 gallons handled of all groups studied. Apparently this size of plant is economical so far as investment in building is concerned. As a general rule the investment per 100 gallons handled increases with the size of the plant up to 10,000 gallons. This is due to a large extent to the fact that the general tendency is for the larger-sized dealers to have more elaborate plants. Although more expensive they serve as an advertising medium. The plants handling more than 10,000 gallons were equally well appearing, but the large quantity handled brought down the investment per 100 gallons. Since these figures were obtained there has been a great increase in the cost of materials, labor, and supplies.

CONCLUSIONS.

1. Conditions should be thoroughly investigated and found to be favorable before attempting to establish a milk plant.

2. For large plants the assistance of a competent architect in making plans is required. Plans for a small plant can often be drawn without such aid.

3. Favorable location of the milk plant is important. In general there are three locations that may be selected for the plant: (1) In a wholesale district; (2) in a down-town retail section; (3) in a residential section. Each of these has its advantages and disadvantages.

4. Plants may be classified, according to the way the milk is handled, into 6 classes. Gravity plants are to be desired, but often the labor required to operate plants of two or more stories is greater than in 1-story plants.

5. Large plants are usually of two or three stories.

6. The milk plant should be modern in every way and should be of good appearance from an architectural point of view.

7. Up-to-date plants are usually constructed of bricks, concrete, or hollow tile, finished on the inside with smooth cement, and on the outside with stucco.

8. Inside walls should have a smooth finish. Tile or enamel brick are desirable for the bottling and pasteurizing rooms.

9. Concrete floors are desirable in all milk plants. Tile floors in the bottling rooms add to the appearance.

10. Floors must be well drained and have proper connection with the sewer.

11. Economical arrangement of the plant is important. There should be an outside loading and receiving platform. It is more economical of labor and time to dump the milk into a tank on the ground floor and then pump it rather than raise it by conveyers or elevators. To unload the milk truck on the inside of the building is an uneconomical arrangement.

12. Where a large number of delivery wagons are to be loaded, loading through 2 or more chutes direct from the storage room will save time. Wagons should be loaded from an exterior platform, and conveyors are more economical in the use of labor and time than hand trucks.

13. In unloading the delivery wagons a conveyer system often saves time and labor.

14. For convenience, economy, and sanitation the plant should be divided into the following separate rooms: Receiving room, pasteurizing or handling room, bottling room, wash room, by-products room, milk-storage room, salesroom, offices, laboratory, etc.

15. Each room should be of ample size to accommodate the equipment it contains, with sufficient space for the men to work and to clean the equipment, but there should be no waste space.

16. The rooms in the plant should be so arranged as to necessitate the minimum expenditure for machinery and labor, and so laid out that the work can be accomplished with the fewest possible steps. There should be a minimum of milk piping and pumps, for both economical and sanitary reasons.

17. Poorly arranged plants tend to increase the labor requirements.

18. The plant should be sanitary in every way; plenty of water and steam should always be available; good ventilation and light are essential.

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